

## MOBILITY AND WHEELCHAIR DESIGN

Although wheelchair technologies continue to improve - providing users with ever increasing options and features- participation in everyday activities at home, work and the community remains a major challenge for people with mobility disabilities. Multiple stakeholders, including insurers, policy makers, manufacturers, health care experts, and users themselves, require a better understanding of how people use these devices in their everyday environments. This information can inform us about how wheelchair type and environment influence health, activity and participation.

Researchers at CATEA use a methodology that accurately quantifies wheelchair activity. The Participation and Activity Monitoring System (PAMS) consists of two parts: 1) a data logger that integrates multiple sensors such as GPS, seat occupancy, and wheel revolution; and 2) a web-based visualization system that presents wheelchair use and geolocation information. This illustration of activity is then shared with the wheelchair user during a prompted recall interview that investigates and contextualizes the data based on recall of destinations, purposes, and transportation modes.

Wheelchair usage information includes distance wheeled, time spent wheeling, time in wheelchair, and number of mobility bouts. Mobility bouts are defined as transitions between activities. Our data suggest that wheelchair usage

should be characterized using the number of mobility bouts and either distance traveled or time spent wheeling. A recently completed study of 25 powered wheelchair users in the Atlanta metro area illustrates how a combination of metrics can be used to fully describe mobility. One-half of the subjects wheeled less than 1 km/day but these same subjects performed between 32-165 mobility bouts on an average day.

Subject	Activity Type	# Visits to Destinations	Distance Wheeled (miles)	# Mobility Bouts	Time Wheeling (min)
A	Work / School	0	0	0	0
	Daily Living Activity	2	0.8	27	27
	Recreation	23	6.7	130	184
	Social	11	0.5	76	27
	Travel	n/a	4.2	66	105
	Total	36	12.2	299	343
B	Work / School	1	0.2	6	10
	Daily Living Activity	15	2.7	202	150
	Recreation	1	0.1	53	29
	Social	1	0	0	0
	Travel	n/a	0.1	6	5
	Total	18	3.1	267	194

Table 1

To illustrate particular differences, Table 1 details the disparate community activity and mobility patterns in two subjects, based on GPS data. Over a 2 week monitoring period, Subject A wheeled 12.2 miles, while Subject B wheeled only 3.1 miles. However, the data illustrates other important differences. Notice that Subject

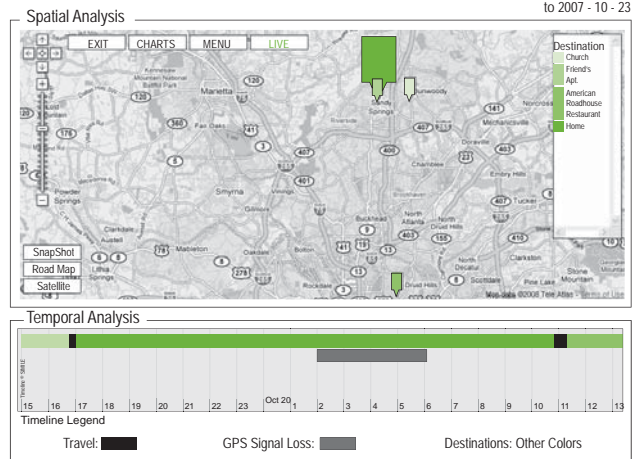
A 'traveled' by wheelchair to his destinations and participated in many recreational and social activities. Most of Subject B's activities consisted of daily living tasks, in this case, visiting her physicians. The ability of Subject A to wheel to destinations appears consistent with a community that permits more spontaneous activity, resulting in fuller community participation.

The PAMS system allows researchers to contextualize activity to study community participation and the built environment. Figure 1 represents a typical PAMS output from a subject monitored over 4 days. She took trips to 3 different destinations as indicated on the map and legend. Temporal analysis is provided by time spent at destinations and travel times. In addition, PAMS is structured to collect detailed information about particular destinations and activities (Figure 2).

The combination of objective measures of activity with subjective, contextual information results in a unique and powerful dataset that will inform future design and policy decisions by addressing questions such as: How does wheelchair design impact community activity and participation for wheelchair users? How does the built environment impact community activity and participation? What community features facilitate or hinder spontaneous community mobility? Does an increase in community activity and participation have an impact on the health of wheelchair users?

### Participation & Activity Monitoring System (PAMS)

Study: PAMS Pilot Study 1 Participant: PLO1, catea Monitoring Period: 2007 - 10 - 19 to 2007 - 10 - 23



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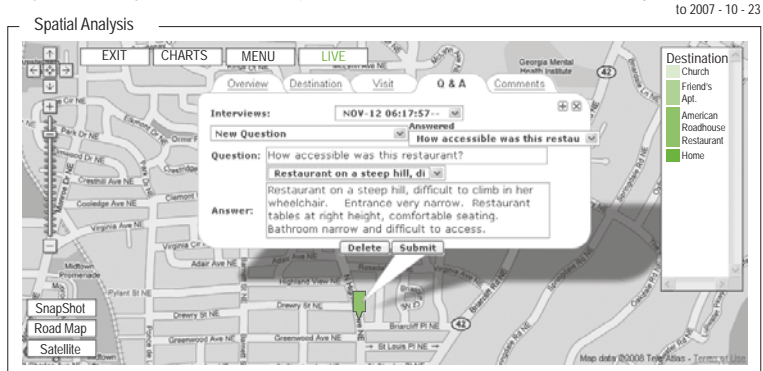


fig. 01

fig. 02

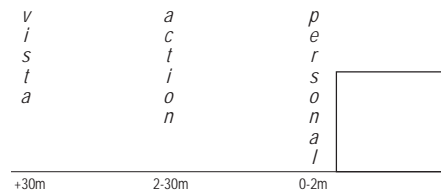
Buildings are not just designed to be seen, they are designed to be seen in particular ways. Linking studies of built form to studies of visual perception and cognition can enhance our appreciation how architecture interacts with and enriches culture. Recent studies by PhD students Carina Antunez, Hyun Kyung Lee, and Myung Seok Hyun working with Associate Professor Sonit Bafna are exploring unconventional approaches to visual case studies in architecture.

Carina Antunez brings recent philosophical work on style and on visual depiction to a study of two 20th century Art Deco buildings in Uruguay. She shows that style is not simply a catalogue of formal motifs and rules of composition, but rather a lens that heightens visual engagement with buildings by evoking deep-rooted cultural imagery.

Myung Seok Hyun brings recent research on reading shape from the depiction of shadow to a study of the influence of photography upon early modern architectural space. Myung's work sharpens our understanding of the deliberate ways in which modernist architects, particularly le Corbusier, carefully modulated shadows in their buildings to produce a distinctive layered spatiality.

A similar analysis of shadows underlies a study by Hyun Kyung Lee. Lee demonstrates how our natural abilities to read depth and three-dimensionality in a view are systematically thwarted by the design moves in Jacques Herzog and Pierre de Meuron's de Young museum in San Francisco (see figure 3). The result is a building that works visually by switching our visual attention to the perceptual activity itself rather than to the object seen.

These studies lead, not just to a sharper interpretive understanding of historical works, but to an understanding of the general issue of why buildings have historically been such complex visual artifacts. Manipulations of the visual form of buildings go far beyond what would be required in response to their programmatic requirements. Buildings present us with ways of seeing as well as with forms and spaces to be seen. A recent paper by Sonit Bafna suggests that these manipulations, often turning buildings into depictive devices, are a means to create visual artifacts that invite, sustain, and reward intense imaginative attention.



*Sets of visual cues to judge relative depth are activated at different distances from the building: greater than 30m (vista space), 2-30m (action space) and 0-2m (personal space)*



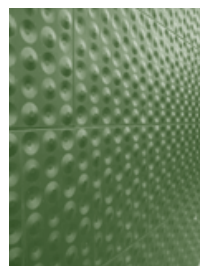
a.



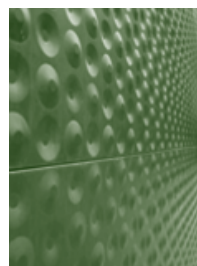
b.



c.



d.



e.

*In the De Young Museum, Jacques Herzog and Pierre de Meuron deliberately manipulate visual cues for depth to create ambiguity in our perception of relative depth; arguably this turns our attention to the perceptual activity itself.*

*Within the "action space" of depth perception:*

- flat facade suppresses cues from binocular disparities, height differences, or convergence and accommodations of the eye [a,b & c]
- micro-shadows dominate over cast shadow and self-shadows
- the lone occluding edge casts ambiguous shadow [c]
- microshadow from punched holes suggests a false fold [b&c (top)]
- microshadow from dimpled surface, and the dull gray color combine to stall perception of actual fold [b&c (below)]

Healthcare facility design provides renewed opportunities to create, strengthen and expand virtuous circles that link research to design, a desideratum that has been repeatedly formulated since the early growth of architectural and environmental research in the 1960s and 1970s. "Evidence-based design" is a call for design decisions to be informed by reviews of available research so that healthcare designs are more likely to support desired medical and organizational outcomes. While the idea of linking design decisions to a relevant research base is not new, the idea of evidence-based design is modeled on "evidence-based medicine", where clinical protocols are evaluated against systematic reviews of research literature and assessments of the quality and quantity of evidence supporting the efficacy of specific clinical decisions.

Significantly, the call for evidence-based design comes at a time when the US is likely to embark upon one of the largest construction programs in history. Most hospitals intend to build a new building in the next two to five years and healthcare construction is expected to exceed \$76 billion per year by 2011. The call for evidence-based design suggests that there will be growing funding for architectural research and a growing impetus to share knowledge and evaluations of precedents so as to strengthen the design profession as a whole, enabling it to make a distinct contribution to the larger agenda of improved health care.

In this context, Dr. Craig Zimring, a leading advocate of evidence based design, has recently edited a special issue of Environment and Behavior to deal with the subject (volume 40, no. 2, March 2008), working with Sheila Bosch, a program graduate. Mahbub Rashid and Debajyoti Pati, also program graduates, have contributed papers. In their introduction, Zimring and Bocsh point to the fact that the Center for Health Design promotes a program that has 42 case-study hospitals currently seeking to enhance healthcare quality through implementing evidence-based design and conducting studies regarding the efficacy of those designs. At the same time, the military health system is beginning to request that design teams apply patient-centered and evidence-based design principles. This is because evidence-based design is seen to have the potential to make health care safer, of higher quality and more patient centered.

At Georgia Tech a large group of students work with Dr. Craig Zimring to contribute to evidence-based design. Current research includes studies pertaining to the role of patient families in the care process in intensive care units (ICUs), the ongoing development of a digital evidence-based design tool consisting of best-practice examples from the healthcare community and the role of computer modeling in pre-construction analysis and evaluations.

fig. 03 (right)  
Depth perception in the De Young Museum, San Francisco, CA

## REAL TIME ADAPTATIVE SYSTEMS FOR BUILDING ENVELOPES

Solar decathlon is a bi-yearly international competition partly funded by the Department of Energy that invites twenty universities to design, build and operate a zero-energy solar house. As an invited participant for the event held in October of 2007, Georgia Institute of Technology's entry for the competition was an experimental house that investigated ways to increase power generation by the photovoltaic (PV) panels and permit maximum daylight penetration, without compromising the comfort conditions inside the house.

The above objectives resulted in a year-long research into real-time adaptive systems for building envelopes, with two specific applications: operable photovoltaic panels and operable shading devices. The first one could track the changing position of the sun to maximize energy production and can also adapt to varying climactic conditions and different locations. The second were proposed as a response to translucent roof panels to regulate internal comfort conditions by controlling direct and indirect solar heat gains.

To achieve the above adaptive features, it required three layers of design operations. First was the design of the mechanics of movement, which tried to achieve the required motion for the PV panels and shading devices using minimum components and parameters. The dimensions of the components for the Photo-Voltaic and shading device assemblies were established using 'Digital Project', a parametric 3-D modeling software that allowed the design team to digitally prototype the mechanism and analyze the motion for any conflicts.

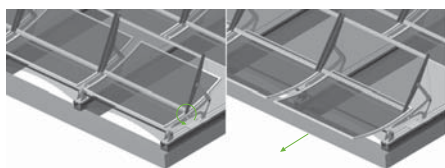


fig. 04  
Verifying motion of Shading Devices  
(Spring, 2007)

Second was the design of the individual parts that were formally consistent with the concept that the architectural design team had developed.

And finally, the third layer was the design of controls that automate the motion of the PV panels and shading devices. This was done using sensors to monitor the existing conditions in terms of a set of input variables, which were then used to actuate the attached motors using the generated output variables. The motion of the PV panels was designed to be governed by a user-defined

schedule that lists the optimal angle for the panels at a given period, which is updated in real-time based on feedbacks from simulation and local weather predictions. The location of the shading devices was decided using a real-time simulation, that checks the indoor thermal environment and determines the percentage of shading required for the roof.

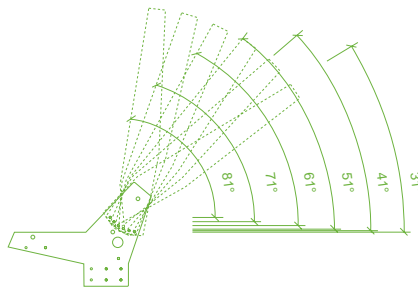


fig. 05  
Aluminum Prototype - Possible Angles Variations  
(Summer, 2007)

The above design operations were facilitated with a series of physical prototypes that were fabricated at the Advanced Wood Products Laboratory (AWPL), a research institute at the College of Architecture, using the available Computer Numerical Control (CNC) machines and Laser Cutters.

The constraint of time restricted some of the research work from being applied to the competition entry; as a result the final design of the operable photovoltaic panel and shading device systems that were developed for the 2007 competition had limited functionality as compared to the initial set objectives. But none-the-less Georgia Tech's Solar Decathlon House proved to be a successful attempt at the integration of the precision and material efficiency of digital fabrication with the self-regulated optimization of controlled mechanisms.



fig. 06  
PV Panels and Shading Devices as installed in Washington D.C. for Solar Decathlon 2007

## COLLABORATIVE TOOLS IN LEARNING ENVIRONMENTS

Communication technologies, both hardware and software, have been changing the dynamics of interaction and collaboration among groups in learning environments.

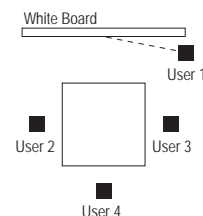


fig 07  
One-Way  
No Computer-Mediated Communication  
Learning Environment

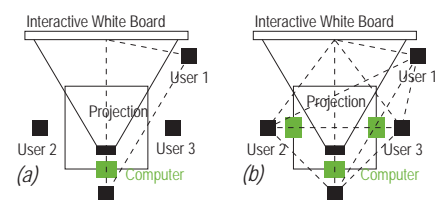


fig 08  
Semi (a) and Multi-Collaborative (b)  
Computer-Mediated Communication  
Learning Environment

In the Industrial Design Program at Georgia Tech, an ethnographic research study was conducted among the senior studio students to assess the impact of computer-mediated communication in the design classroom. The research was sponsored by PolyVision, a Steelcase company focused on creating cutting-edge instructional products and services that inspire users to be more productive, effective and creative when collaborating. The company product design goal is to enhance the way people learn, work, and communicate visually. Thunder Express is one of the company's product portfolio that uses a self-designed software, interactive boards and projections to generate a collaborative experience among users located in the same room or at a distance. Thunder Express allows users to input information from different sources such as personal computers, tablets, scanners and interactive boards to mention a few. The software allows multiple users and devices to work collaboratively in the same room or at a distance, and virtually any content can be shared synchronously across space.

The primary research goal was to determine how design faculty and students utilize collaborative communication technologies in the classroom environment and compare the experience among first-time user and those who use across-time. Three Thunder Express products were placed in a studio accessible to students at all times; a



conference classroom accessible for seminar classes; and a conference room accessible only to faculty. Research was conducted through observations, surveys and interviews in the three aforementioned settings. Each group setting was videotaped for six sessions using Thunder Express, where three of the group were first-time users. During observations, little to no instruction was given about the use the product. A fixed survey questionnaire was used following each session with all participants. Survey questions were given about the product's ease of use, satisfaction, collaboration levels and task completion. Lastly, one participant from each session was randomly selected to participate in a semi-structure face-to-face interview. Interview questions were related to describing their experience in terms of understanding the capabilities and limitations of the product.

While the results are currently being tabulated and analyzed for in-depth understanding, the most important preliminary finding suggests that satisfaction with the product is higher for first-time users than those who use it over time. Over time and with increased user expectations, the product becomes harder to use and less integrated into the thinking style needs and interactive goals of the group. This was best explained by a user: "Couldn't use it the way we needed to work to move forward." Generally, group task goals were not fully met, but positive task completions with the product included the repository feature of interactions among a group. Thinking processes were visualized and archived for continuous and accumulative access. The product's positive impact on collaboration was higher for settings with a higher number of long-time users with laptop/tablet computers, suggesting that the more exposure to the product a user has, the better their understanding of the product's collaborative capabilities. For first-time users the collaborative opportunities were not evident. Even though the product had powerful collaborative tools, users often failed to embrace the full technological capabilities and pursued basic and traditional/physical teaching and learning behaviors. Generally, when the collaborative tools were used, users acknowledged working more effectively as a group: "I think it helped us pay attention as a group."

In summary, the longer the use of collaborative the tools in the classroom, the higher the need for tools that allow more natural interactions and thinking styles. For a multidirectional computer-mediated communication model to effectively work in learning environment, there is a need to design more fluid products that blend with the educational experience. The user shouldn't have to make an effort to think about the tools.

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## PROCEEDINGS

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Augenbroe G, "Design and construction industry trends survey", American Council of Engineering Companies, \$17,500

Zimring C, Augenbroe G, Bafna S, DuBose J, "Supporting LSU in creating an excellent evidence-based hospital", Robert Wood Johnson Foundation \$214,000

CATEA, "Development and testing of the next version of the wound measurement device", IP2Biz. The project will complete development and perform clinical testing of a new wound measurement device developed at Ga Tech and licensed to IP2Biz

CATEA, "Disability case study research consortium on employer organizational practices in employing people with disabilities", Syracuse University

CATEA was awarded a grant last fall to continue research and development as the national Rehabilitation Engineering Research Center on Workplace Accommodations (Work RERC) for another five years. The Work RERC will identify, develop and promote new assistive and universally designed technologies that maximize independence and participation of people with disabilities in the workplace.

Nancey Green Leigh joins the ranks of other distinguished planners of Fellows of the American Institute of Certified Planners (AICP). She was inducted into the College of Fellows at the American Planning Association's National Conference in Las Vegas this April. The election as a Fellow is the highest honor bestowed by AICP, recognizing the recipient as a model planner who has made significant contributions to planning and society. Leigh's work focuses on the area economic development planning. She is the first woman to receive this honor in the state of Georgia.

Robert Craig was awarded the 2008 President's Award of the Nineteenth Century Studies Association recognizing contributions to 19th century studies and sustained service to the association. The award is the society's life-time achievement award.

Stephen Sprigle was awarded a Centers of Innovation Research Grant from Governor Sonny Purdue's OneGeorgia Authority program, which is designed to spur economic development in rural Georgia.

CATEA is joining the International Council for Research and Innovation in Building (CIB), the National Research Council, and the Construction Technologies Institution in organizing the Working Commission 084 "Building Comfortable Environments for All" to be held on May 15-16, 2008, at the Georgia Tech College of Architecture.

Dr. Do was on a site visit team for National Science Foundation's Science of Learning Center to evaluate and recommend up to 12 million dollars of grant funding decisions.

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## GRANTS

## ACTIVITIES

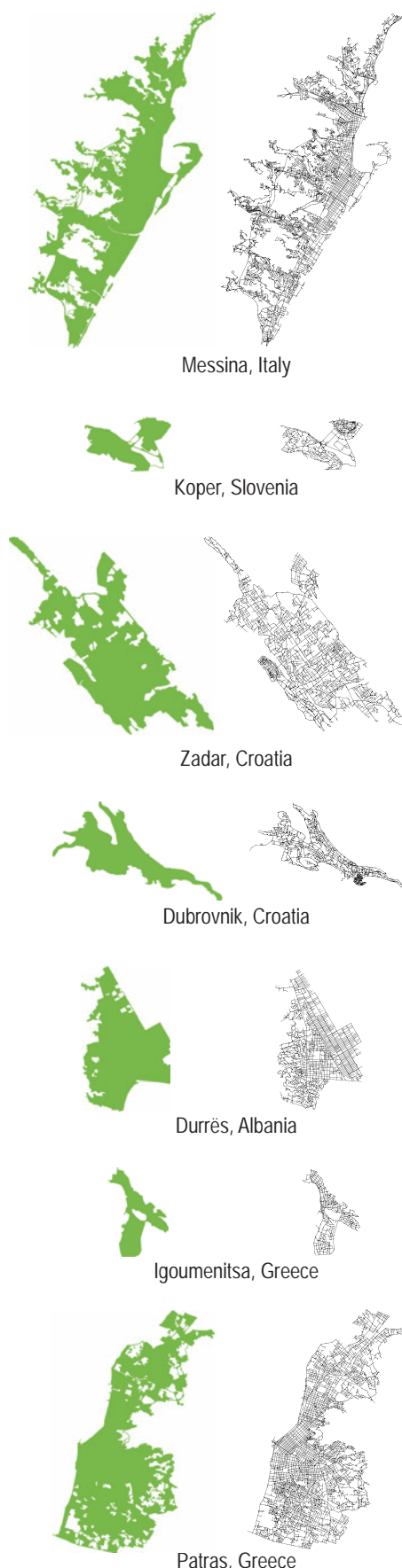
## PRESENTATIONS

## DISTINCTIONS

# Alumni

Dr. Sung Hong Kim (1995 graduate) working with Peter Cachola Schmal has edited the book "Contemporary Korean Architecture", which was recently been published by Jovis for the Deutsches Architekturmuseum and the Korean Architects Institute to coincide with an exhibition. In the tradition of similar books published for the Deutsches Architekturmuseum, the book includes essays on Korean architecture and urbanism as well as a great variety of built projects. As Kim notes, the book documents Korean architecture at a time when "global architectural trends are becoming less something that Korean architects are being influenced by and more something that they are part of." The interaction of regional and international architectural traditions occurs at a time of rapid urban growth, which has led to large urban regions on the one hand and to extremely high densities in urban centers on the other; for example, the average plot size in Seoul is 267 sq meters. Thus, architecture assumes a particular vertical intensity. "Contemporary Korean Architecture" explores the opportunities and constraints afforded by inherited urban morphologies and by projects of urban expansion.

Dr. Eral Shpuza (2005 graduate) is currently Assistant Professor at the Department of Architecture at Southern Polytechnic State University, Marietta, GA. He coordinates and teaches third year design studios that address adaptive reuse and environmental design; environmental technology core courses; and, the Germany Study Abroad Program. He has initiated Space Lab, an elective course on the spatial morphology of domestic space, complex buildings and urban environments. His current research focuses on the interaction between urban shape and structure. Extending the methodologies and findings of his doctoral research on office floorplates and layouts, he has discovered consistent patterns of interaction between urban shape and the structure of street networks in a sample of fifty coastal cities located in the Adriatic and Ionian region in Southern Europe. He is currently pursuing archival research on twenty-five coastal towns in Italy, Croatia, Albania and Greece and investigating how the relationship between shape and structure changes throughout their historic evolution.



## PhD Focus

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fig. 09 (right)  
*Urban Shape and Structure of Adriatic and Ionian  
Coastal Cities*